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27th March 2017

Modern Concurrency: async and await

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Today we'll talk about Concurrency in Modern JavaScript.

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Concurrency

Doing multiple tasks in a period of time.

(Generally order-independent or partially-ordered units of work)

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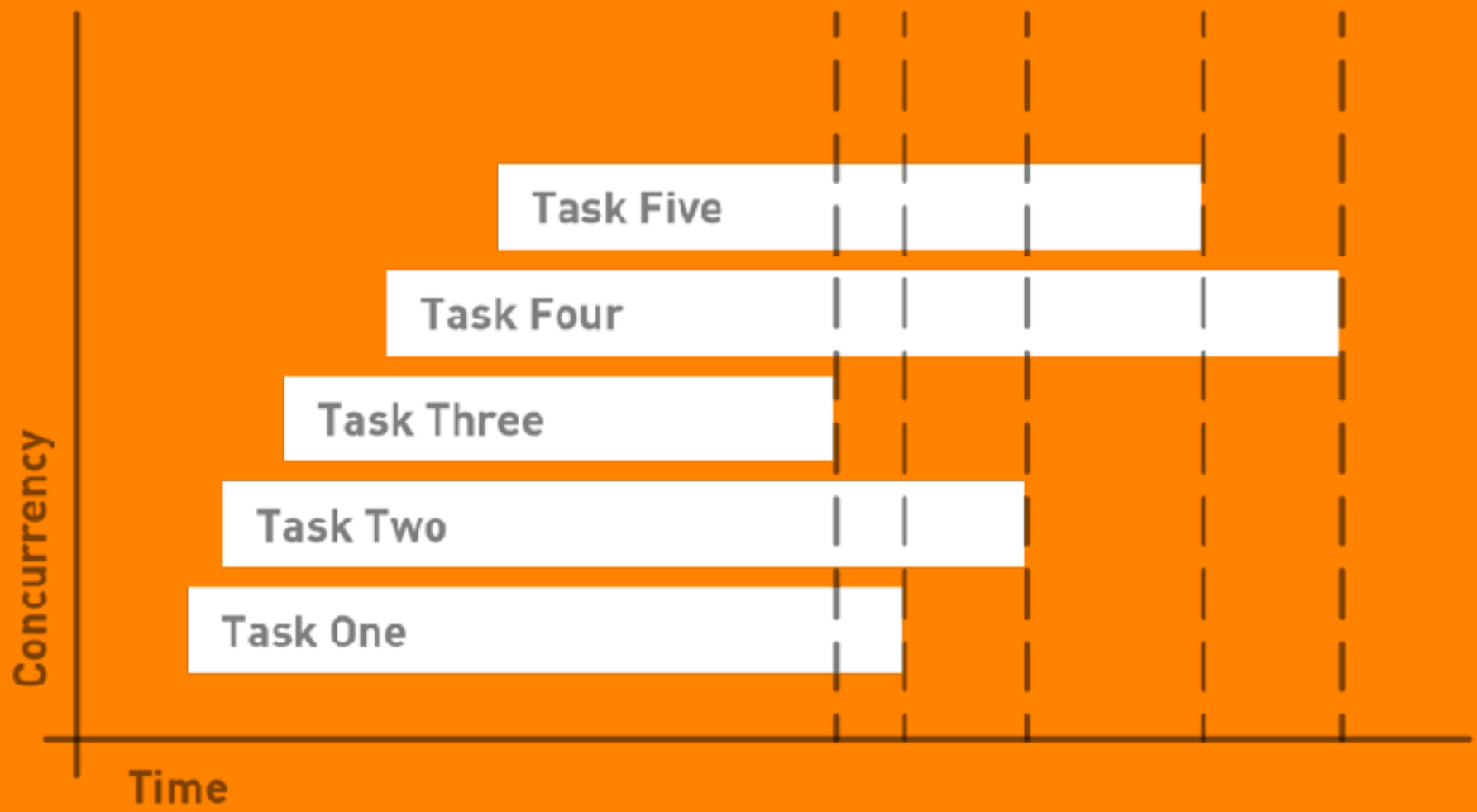
Concurrency



Concurrency is important when waiting on input/output such as network requests, reading/writing from disk, or user input.

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Typically, two ways programs wait for IO:

- blocking (“synchronous”)
  - Easy to write
  - Uses multi-threading
  - Memory and context-switching overhead
- non-blocking/event-loop (“asynchronous”)
  - Single-threaded
  - High-concurrency with low-memory consumption
  - Great for UI and IO-bound services rather than CPU-bound

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All modern JavaScript engines use the non-blocking/event-loop approach.

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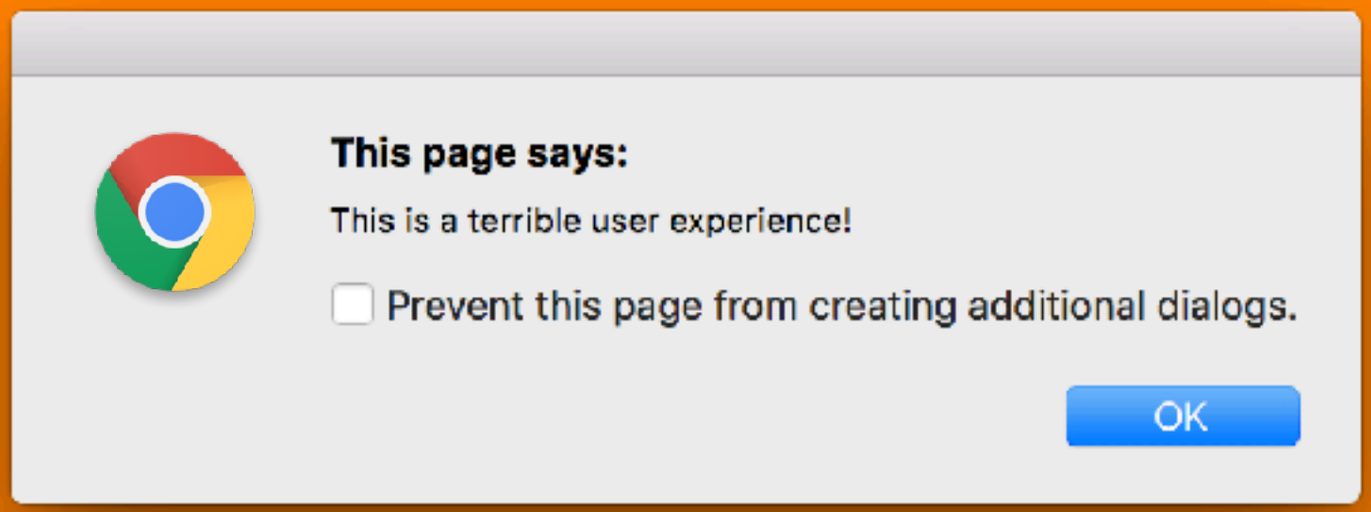
So what happens if you block in JavaScript?

There are a few things that will block:

- alert/prompt/confirm
- synchronous XMLHttpRequest (rare)
- fs.readFileSync and friends in Node



Blocking in the browser will halt everything, including all user interaction, even scrolling.

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Callbacks

Just pass a function that will be called when the task is complete.

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Callbacks

```
// Callback style
readFile('file.txt', (content) => {
  console.log(content);
});
```

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Callbacks

Pros:

- **Great low-level abstraction**
- **Performant with low overhead**
- **Can do almost any async task with callbacks**

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Callbacks

Cons:

- **Doing things in sequence is hard. Doing things in parallel is harder!**
- **Give up constructs such as for/while and try/catch**
- **Error handling is difficult**
- **Code readability suffers and systems become hard to maintain**

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```
// Every day on StackOverflow
function getUserName() {
  let name;
  $.get('/users/123', (user) => {
    name = user.name;
  });
  return name;
}

// Why doesn't it work??
console.log('User Name:', getUserName());
```

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Callbacks Add Complexity

It's messy to chain tasks and difficult to do parallelism.

```
// Sequential tasks (even without error handling)
function getTotalFileSize(file1, file2, file3, callback) {
  let total = 0;
  stat(file1, (error, info) => {
    total += info.size;
    stat(file2, (error, info) => {
      total += info.size;
      stat(file3, (error, info) => {
        total += info.size;
        callback(total);
      });
    });
  });
}
```

```
// Parallel tasks (without error handling)
function getTotalFileSize(file1, file2, file3, callback) {
  let numFinished = 0;
  let total = 0;
  [file1, file2, file3].forEach((file) => {
    stat(file, (error, info) => {
      total += info.size;
      numFinished += 1;
      if (numFinished === 3) {
        callback(total);
      }
    });
  });
}
```

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Plus Error Handling

We spend a lot of effort checking if an async task failed.

We completely lose try/catch.

```
// This is not even good Error handling.
stat(file1, (error, info) => {
  if (error) {
    console.error(error);
    return;
  }
  total += info.size;
  stat(file2, (error, info) => {
    if (error) {
      console.error(error);
      return;
    }
    total += info.size;
    stat(file3, (error, info) => {
      if (error) {
```

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Readability Issues

When code readability is this bad, we're more likely to let errors sneak in.

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OK, Let's talk about Promises.

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The Promise Land

Thin but powerful abstraction on top of callbacks.

Solves several problems:

- **Easy chaining; sequential/parallel tasks**
- **Error handling**
- **Composable; can pass around a representation**

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```
// Promise style
readFile('config.json')
.then(...)
.catch(...);
```

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It's better, I Promise

In it's basic form, it looks no better than callback style.

.. but you actually get a lot more.

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Chaining Promises

```
sleep(1000)
  .then(() => {
    console.log('one');
    return sleep(1000);
  })
  .then(() => {
    console.log('two');
    return sleep(1000);
  })
  .then(() => {
    console.log('three');
  });
```

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Flow Control

We can easily combine sequential and parallel tasks to create advanced flows.

```
// This would be very difficult with callbacks
fetchJSON('/user-profile')
  .then((user) => {
    return fetchJSON(`/users/${user.id}/friends`);
  })
  .then((friendIDs) => {
    let promises = friendIDs.map((id) => {
      return fetchJSON(`/users/${id};`);
    });
    return Promise.all(promises);
  })
  .then((friends) => console.log(friends));
```

Error Handling

Attach a single catch()

Exceptions will bubble up similar to how it works in synchronous code.

```
fetchJSON('/user-profile')
  .then((user) => { ... })
  .then((friendIDs) => { ... })
  .then((friends) => { ... })
  .catch((error) => {
    console.error('And error occurred.');
});
```

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But we're still putting callbacks inside .then()

Can we do better?

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```
// What we want
let promise = fetch('/users');
// TODO: Somehow wait for the promise to resolve
console.log(promise.result);
```

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But JavaScript is fundamentally single-threaded.

So we still can’t block.

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However...

There is a special thing called a "Generator Function" that can be paused.

```
function* generatorFunc() {
  let result = fetch('/users');
  // Pause execution by yielding.
  yield result;
  // Later something caused us to resume.
  console.log(`We're back!`);
}
```

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Promises + Generators =

Awesome!

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async/await

is basically a thin layer of syntax

over Promises and Generators

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```
async function getUsers() {
  // Here's the magic
  let result = await fetchJSON('/users');
  console.log(result);
}
```

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Total Win

We get back most of our traditional constructs:

- **for/while**
- **try/catch**
- **readable, sequential program flow**
- **powerful inter-op with promises**

```
async function readConfig() {
  try {
    let content = await readFile('config.json');
    let obj = JSON.parse(content.toString());
    console.log(obj);
  } catch (error) {
    console.error('An error occurred', error);
  }
}
```

```
async function animate(element) {
  for (let i = 0; i < 100; i++) {
    element.style.left = i + 'px';
    await sleep(16);
  }
}
```

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It's just promises

- An async function always returns a promise.
- When we await a promise, our function pauses until the promise is ready (resolved)
- We can still use all our favorite promise helpers such as Promise.all()

```
async function getUserFriends() {
  let user = await fetchJSON('/users/me');
  let friendIDs = await fetchJSON(`/friends/${user.id}`);
  let promises = friendIDs.map((id) => {
    return fetchJSON(`/users/${id}`);
  });
  let friends = await Promise.all(promises);
  console.log(friends);
}

let promise = getUserFriends();
```

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Pro Tips

- Don't forget to await!
- Be careful about doing too much sequentially when you can actually do it in parallel
- Using await in map/filter won't do what you might expect!
- Even though it looks synchronous, remember your code has been paused/resumed

```
async function getNameAndAge() {
  let name = await readLine('What is your name? ');
  console.log(`Your name: ${name}`);
  let age = await readLine('What is your age? ');
  console.log(`Your age: ${age}`);
  console.log('Thank you!');
  process.exit();
}
```

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You can use this Today!

- Chrome
- Firefox
- Node
- Use Babel for the rest.

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Thanks for Listening!

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